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MISCELLANEOUS PAPER NO. 4-819

DUST ALLEVIATORS

Report 1

RESIN- AND LATEX-BASE CONCRETE CURING COMPOUNDS

by

J. L. Decell

Best Available Copy



June 1966

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U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS

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Report I

RESIN - AND LATEX-BASE CONCRETE CURING COMPOUNDS

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J. L. Decell



June 1966

Sponsored by

U. S. Army Materiel Command
Project No. 1-V-0-21701-A-047

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG MISS

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FOREWORD

General authority for this investigation was contained in Research and Development Project 1-V-O-21701-A-047, "Transportation Environmental Research Studies." Previously, responsibility for this project was assigned to U. S. Army Transportation Research Command (USATRECOM) at Ft. Eustis, Virginia.

The tests reported herein were conducted in the U. S. Army Engineer Waterways Experiment Station (WES) Surface Effects Blast Facility during February and March 1965 by personnel of the WES Soils Division under the general supervision of Messrs. W. J. Turnbull, W. G. Shockley, A. A. Maxwell, and W. L. McInnis, and under the direct supervision of Mr. G. W. Leese. This report was prepared by Mr. J. L. Decell.

Director of the WES during this investigation and the preparation of this report was Col. J. R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

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SUMMARY

The downwash of the rotors and exhausts of helicopters and vertical takeoff and landing (VTOL) aircraft creates hazardous dust clouds and airborne debris during takeoffs and landings. In efforts to find a means of alleviating this problem, several compounds were tested to determine their effectiveness in preventing dust cloud formation when applied to soils. The liquids tested were resin-base and latex-base concrete curing compounds which dry to a smooth, moderately flexible, plastic film on contact with air.

The compounds were applied to 5- by 5-ft areas of two types of soil, a CL clay and a fine- to medium-grained sand. The treated areas were allowed to cure and were then tested with a six-bladed fan which produced a disc load of 13.5 psf and velocities across the surface of the area averaging approximately 4000 fpm.

As a result of these tests, the following conclusions were evident:

- a. Neither compound could be used in traffic areas.
- b. The compounds could be used as dust alleviators in such non-traffic areas as the fringe areas of helicopter landing pads, runways, or rocket launch pads.
- c. The resin-base curing compound performed satisfactorily on the sand, but not on the loess.
- d. The latex-base compound performed satisfactorily on the loess, but not on the sand.
- e. When wetted to simulate exposure to rain, the resin-base compound applied to sand failed under testing.

It is recommended that more extensive tests be conducted to evaluate other compounds for use as dust alleviators. Tests should be performed using larger test areas and higher disc loads, with variations in application techniques. These compounds should also be tested under the downwash of a jet engine in order to evaluate their performance under conditions of jet VTOL and STOL aircraft.

DUST ALLEVIATORS

RESIN- AND LATEX-BASE CONCRETE CURING COMPOUNDS

PART I: INTRODUCTION

1. Since the advent of the helicopter and other vertical takeoff and landing (VTOL) aircraft, one of the major problems encountered in their use is the generation of dust clouds and airborne debris. These dust clouds and airborne debris, produced by the downwash of rotors and exhausts, have completely obscured visibility for pilots during takeoffs and landings, and have damaged aircraft through ingestion into engine intakes and contact with rotor blades. Flying debris and dust are also detrimental to ground facilities and support personnel. The alleviation of dust and debris has been attempted and studied by many agencies using many different materials and compounds, with varying degrees of success.

2. This report describes and gives the results of tests performed at the U. S. Army Engineer Waterways Experiment Station (WES) to determine the effectiveness of two sprayable compounds when applied to soils as dust alleviators.

PART II: TEST MATERIALS, TEST SAMPLES, AND EQUIPMENT

Test Materials

3. Two types of soils, Vicksburg loess and Reid Bedford sand, were used in this investigation. The loess (a clay classified as CL according to the Unified Soil Classification System) has a specific gravity of 2.70 and a wet density of 108.8 pcf. A grain-size distribution curve for this loess is shown in plate 1. The Reid Bedford sand is classified as a fine-to-medium sand, and had an average water content of 14.8 percent and a wet density of 95.2 pcf. A grain-size distribution curve for this sand is also shown in plate 1.

4. The two liquid compounds tested for possible use as dust alleviators were manufactured by the Hunt Process Corporation - Southern, Ridgeland, Miss. These compounds, one a latex base and the other a resin base, are used primarily as concrete curing compounds. They are liquid and, upon contact with air, dry to a smooth plastic film of moderate flexibility.

Sample Preparation and Application of Compounds

5. The soil materials were tested in a 5-ft by 5-ft by 6-in.-high test frame (photograph 1). The loess material was placed in the test frame and compacted with an air-actuated tamper until no further noticeable compaction took place. The sample was then smoothed with a screed. The Reid Bedford sand was placed loosely in the frame and smoothed with the screed. No compaction on the sand was attempted. When a test was performed without the application of a compound and the samples were blown away, additional sand or loess was added to the test area to repair it to the original condition before the next test. In the case of a treated test area, the soil was removed after a test to a depth below the penetration level of the compound and new soil was added in preparation for the next test.

6. Both the resin-base and latex-base compounds were applied to the test area with a compressed-air concrete-curing-compound sprayer. The surface of the test area was covered uniformly with 1/2 gal of compound. Photograph 1 shows the sprayer nozzle as resin-base compound is being applied. Both the resin- and latex-base compounds were allowed to cure for 1 hr before any testing was performed.

Test Equipment

7. The tests were conducted using a 6-bladed, 20-in.-diam nonducted propeller (photograph 1). The propeller was situated two diameters (40 in.) above the test area surface and produced a disc load of 13.5 psf. The propeller was driven by a variable-speed electric motor; the speed of the motor was monitored by a proximity type transducer. The output of the transducer was fed to an electronic counter, providing a constant check on the propeller speed.

8. The velocity of the downwash across the sample surface was measured by pitot tubes and a 32-tube manometer board. The pitot tubes were installed at two edges of the test area, 90 deg apart. The deflections on the manometer board were recorded by photographing the board with a permanently mounted, 4 by 5, polaroid camera. The velocities as measured by the pitot tubes averaged approximately 4000 fpm.

PART III: TESTS AND RESULTS

Test Program

9. The loess soil was tested untreated and after treatment with each of the two compounds. The sand was tested under the same three conditions, and under an added condition of light wetting of the test area after it had been treated with the resin-base compound. A summary of the test program is given in table 1. The following paragraphs present observations and results of the tests.

Tests of Untreated Soils

Loess

10. The loess was placed, compacted, and leveled as described in paragraph 5. Photograph 2 shows the untreated loess before testing. The propeller was then run, subjecting the test area to a disc load of 13.5 psf for 120 sec to determine the effect of the downwash velocities on the untreated loess. The very fine dust and very small particles (less than 1/4 in.) were blown away in the first few seconds of testing. After the first 60 sec, practically all of the small particles had been removed from the test area and a few of the larger pieces (1/4 to 3/4 in.) were beginning to be dislodged. The texture of the surface after 60 sec of testing is shown in photograph 3. During the last 60 sec, large pieces of loess (1 to 2 in.) began to break away from the surface of the test area. Once these large pieces were dislodged, they broke into smaller pieces due to saltatory action, and were blown away. Other large pieces were merely dislodged and remained in the test area, as shown in photograph 4. Velocities measured at the soil surface during the tests are given in table 1.

Reid Bedford sand

11. The sand was placed loosely in the 5-ft by 5-ft by 6-in.-high test frame with no compaction effort. It was then leveled to achieve a smooth, uniform surface. The test area before testing is shown in photograph 5. The test area was then subjected to a disc load of 13.5 psf for 60 sec to determine the effect of the propeller downwash on the untreated sand sample. The sand became airborne immediately and continued to move throughout the test (photograph 6). As can be seen in photograph 7 (taken after 60 sec of testing), a considerable amount of sand was removed from the test area. The buildup of sand in the center of the sample, directly under the propeller, is typical of the downwash flow patterns of the propeller. Velocities measured in this test are shown in table 1.

Tests of Soils Treated with Resin-Base Compound

Loess

12. After the untreated test, the loess test area was refilled, re-compacted, leveled, and sprayed uniformly with 1/2 gal of resin-base compound and allowed to cure for 1 hr. Photograph 8 shows the treated loess after curing and before testing. The propeller was then run for 120 sec, producing a disc load of 13.5 psf (velocities are shown in table 1). Photograph 9 shows the test area after 60 sec of testing. The pattern of soil movement was similar to that observed during tests on the untreated soil with one notable exception. Initially, there were not as many fines to be blown off and almost no dust was generated. Although the compound did not seem to appreciably affect the total amount of soil set in motion, it did hold the large pieces together as they were dislodged, and these large pieces rolled away from the test area rather than breaking up and becoming airborne. The surface of the treated test section after 120 sec of testing is shown in photograph 10.

Sand

13. After the untreated test, the sand test area was refilled, sprayed with 1/2 gal of resin-base compound, and allowed to cure for 1 hr. Photograph 11 shows the test section before testing. The test area was then subjected to a disc load of 13.5 psf for 120 sec (velocities are shown in table 1). Photograph 12 shows the test area during the test after the propeller had run approximately 60 sec. Very little sand had left the sample at this point. The only sand grains that were moved were those that were not adhered by the compound, and these were blown away during the first 2 sec of testing. Photograph 13 shows the sample after 120 sec of testing. Comparison of photograph 13 with photograph 11 reveals no noticeable difference in the surface of the treated sample before and after testing.

Tests of Soils Treated with Latex-Base Compound

Loess

14. The loess was prepared and sprayed with the latex-base compound, and allowed to cure for 1 hr. Duration of testing for this specimen was 30 sec at a disc load of 13.5 psf. Photograph 14 shows the test area after curing and before testing. Difficulty with the sprayer was experienced during application of the latex-base compound and nonuniformity of application resulted. After 15 sec of testing, part of the test specimen had been dislodged and blown away (photograph 15). Some of the specimen blew away in rather large (up to 2 in.) but relatively thin (1/4 in.) pieces. Photograph 16 shows the test area after 30 sec of

testing. As can be seen, much of the specimen failed after only 30 sec, although failure was not as uniform throughout the sample as it was for the loess treated with the resin-base compound. Velocities measured during the test are given in table 1.

Sand

15. The sand test specimen was prepared and sprayed with the latex-base compound, and allowed to cure. Photograph 17 shows the treated sand specimen before testing. The test was performed at a disc load of 13.5 psf for 30 sec (velocities are shown in table 1). The specimen started failing almost immediately after the test began and after 15 sec of testing, approximately 80 percent of the treated surface had blown away (photograph 18). Photograph 19 shows the test area after testing for 30 sec; almost the entire surface of the sample was destroyed. The center area remaining was due to a "dead area" that is characteristic of the downwash flow pattern of the propeller.

Tests of Resin-Base Compound on Sand with Simulated Rainfall

16. A specimen of Reid Bedford sand was prepared in the usual manner and treated with 1/2 gal of resin-base compound. The compound was allowed to cure for 1 hr. The test area was then subjected to a disc load of 13.5 psf for 240 sec with no noticeable effect, as was the case in the previous test with the sand and resin-base compound (table 1 shows test velocities). The test specimen was then sprayed with a fine mist of water for 30 min to simulate a light-to-medium rainfall, and the propeller was again run for 240 sec at a disc load of 13.5 psf (see table 1). Photograph 20 shows the erosion taking place during the test after approximately 120 sec of running time. Photograph 21 shows the test area after testing. Test specimen failure took place after approximately 60 sec of testing under the wetted condition.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

17. The compounds used in these tests did not perform uniformly in that a given type compound produced different results on sand than it did on loess.

18. As a result of the observations made and a close study of the data obtained, the following conclusions are evident:

- a. The untreated loess test specimen exhibited immediate signs of failure as the test began.
- b. Treatment of the loess with the resin-base compound did not stabilize the material to any appreciable degree.
- c. Treatment of the loess with latex-base compound provided dust alleviation.
- d. Untreated Reid Bedford sand failed immediately.
- e. Treatment of the sand with the resin-base compound provided excellent dust alleviation.
- f. Treatment of the sand with the latex-base compound did not provide dust alleviation.
- g. After being sprinkled with water, the sand test specimen treated with resin-base compound failed completely.
- h. Both compounds should be used only in nontraffic areas such as the fringe areas of helicopter landing pads, runways, or rocket launch pads.

19. As a result of the tests performed and the conclusions drawn, it is recommended that:

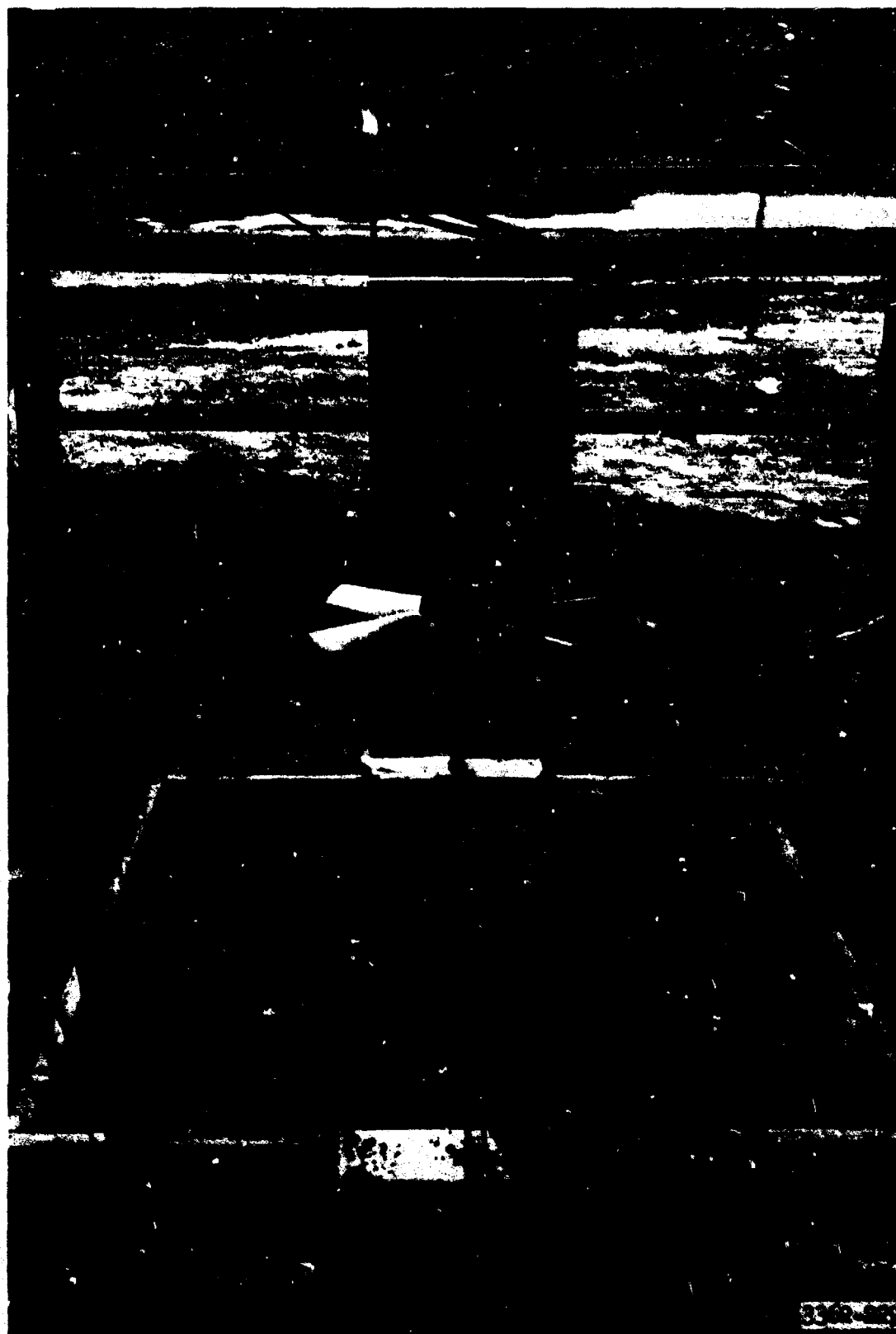
- a. The resin-base compound be used on sand or highly sandy soils.
- b. The latex-base compound be used for treatment of clay-type soils.
- c. Neither compound be used in traffic areas.
- d. Testing be continued using higher disc loads, larger test areas, different types of compounds, and variations in application techniques. Testing should also be conducted using jet engine exhaust to determine the effectiveness of alleviators when simultaneously subjected to heat and down-wash pressures.

Table 1

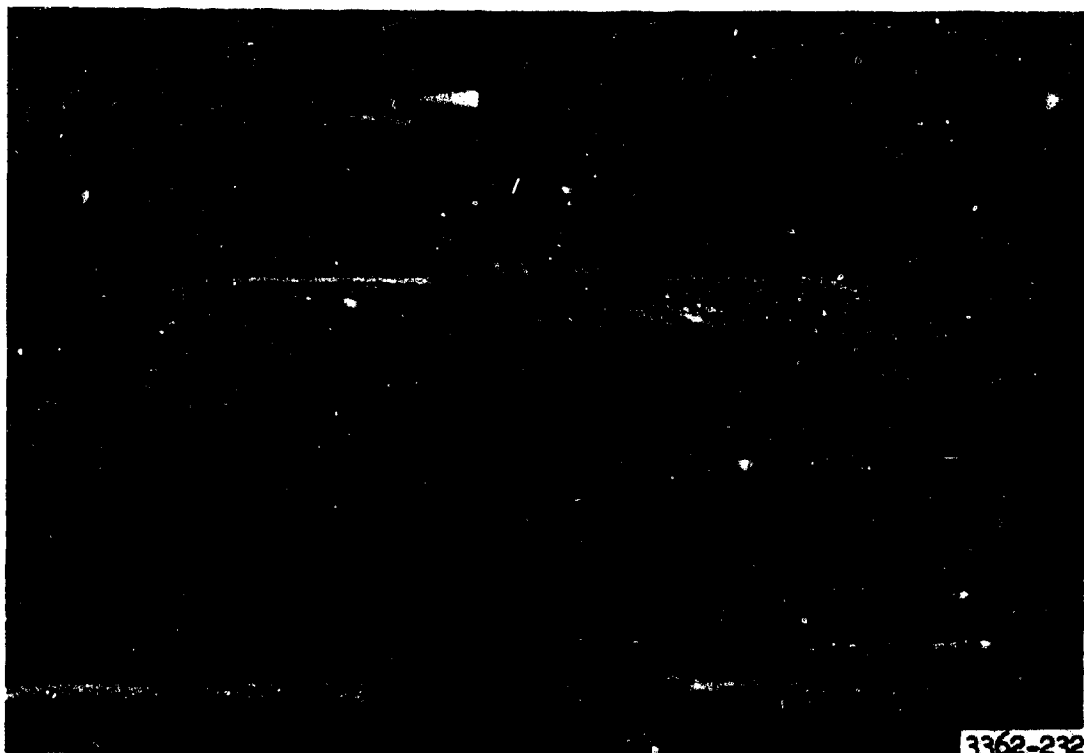
Test Program and Velocities Measured During Tests

Duration of Test sec	Soil Type	Sample Description	Velocity Across Soil Surface, fpm	
			Top Probe	Bottom Probe
120	Loess	Untreated	4500	4175
120	Loess	Treated with resin-base compound	4390	3850
30	Loess	Treated with latex-base compound	4620	4480
60	Reid Bedford sand	Untreated	3390	2050
120	Reid Bedford sand	Treated with resin-base compound	4520	3940
30	Reid Bedford sand	Treated with latex-base compound	3660	2230
240	Reid Bedford sand	Treated with resin-base compound	4280	2706
240	Reid Bedford sand	Treated with resin- base compound and sprayed* with water	4280	2290

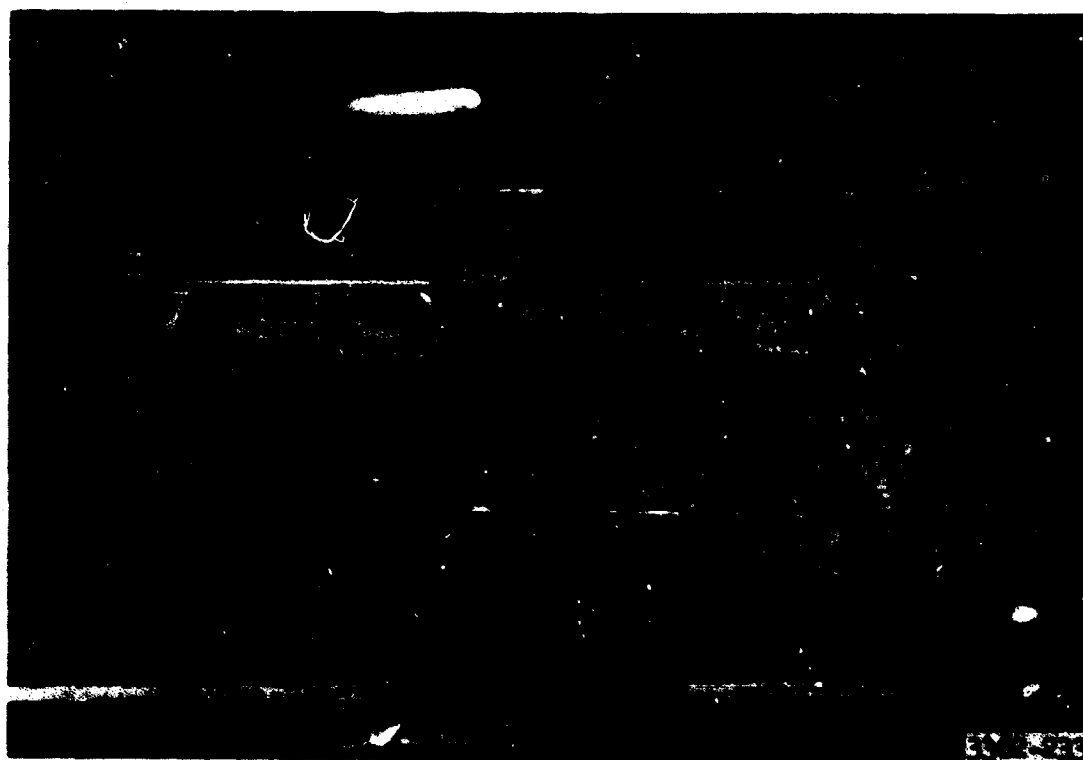
* Sprayed with water after curing for 1 hr to simulate light rainfall.



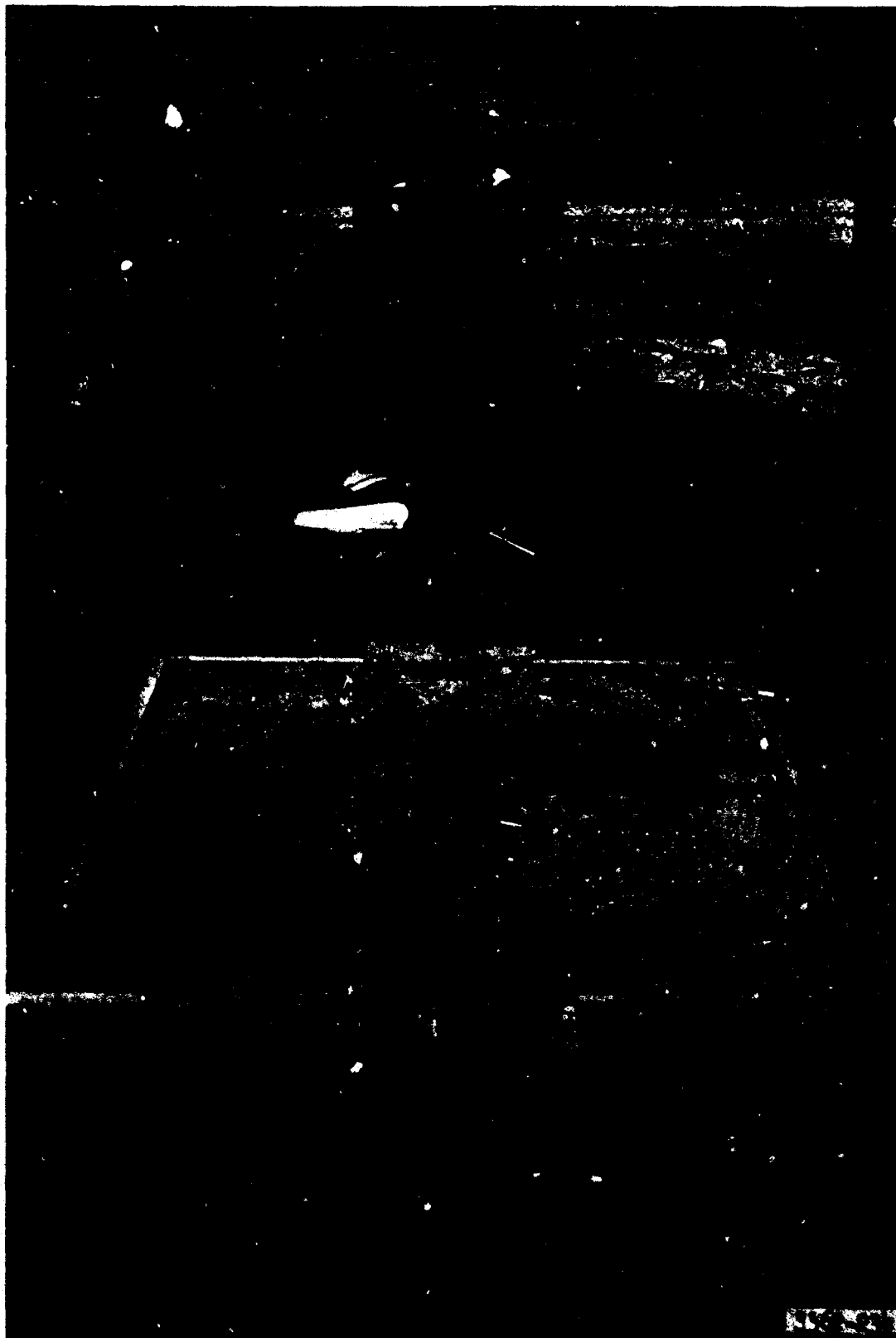
Photograph 1. Application of resin-base compound to loess sample



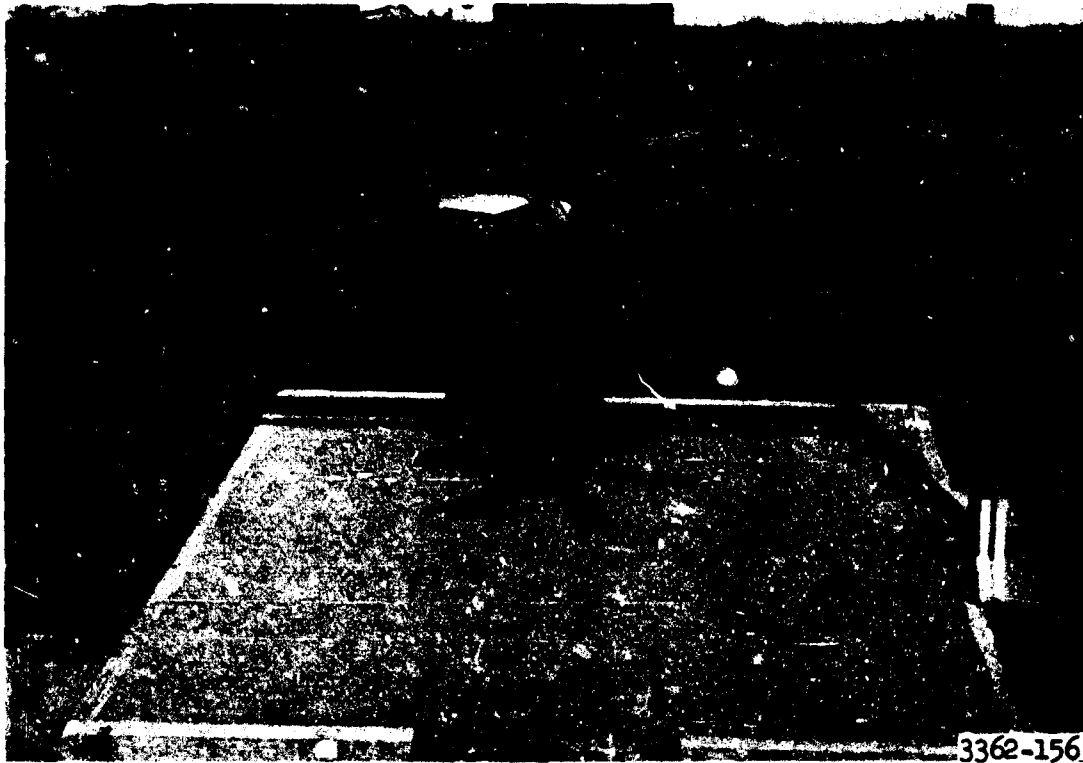
Photograph 2. Untreated loess before testing



Photograph 3. Untreated loess after 60 sec of testing



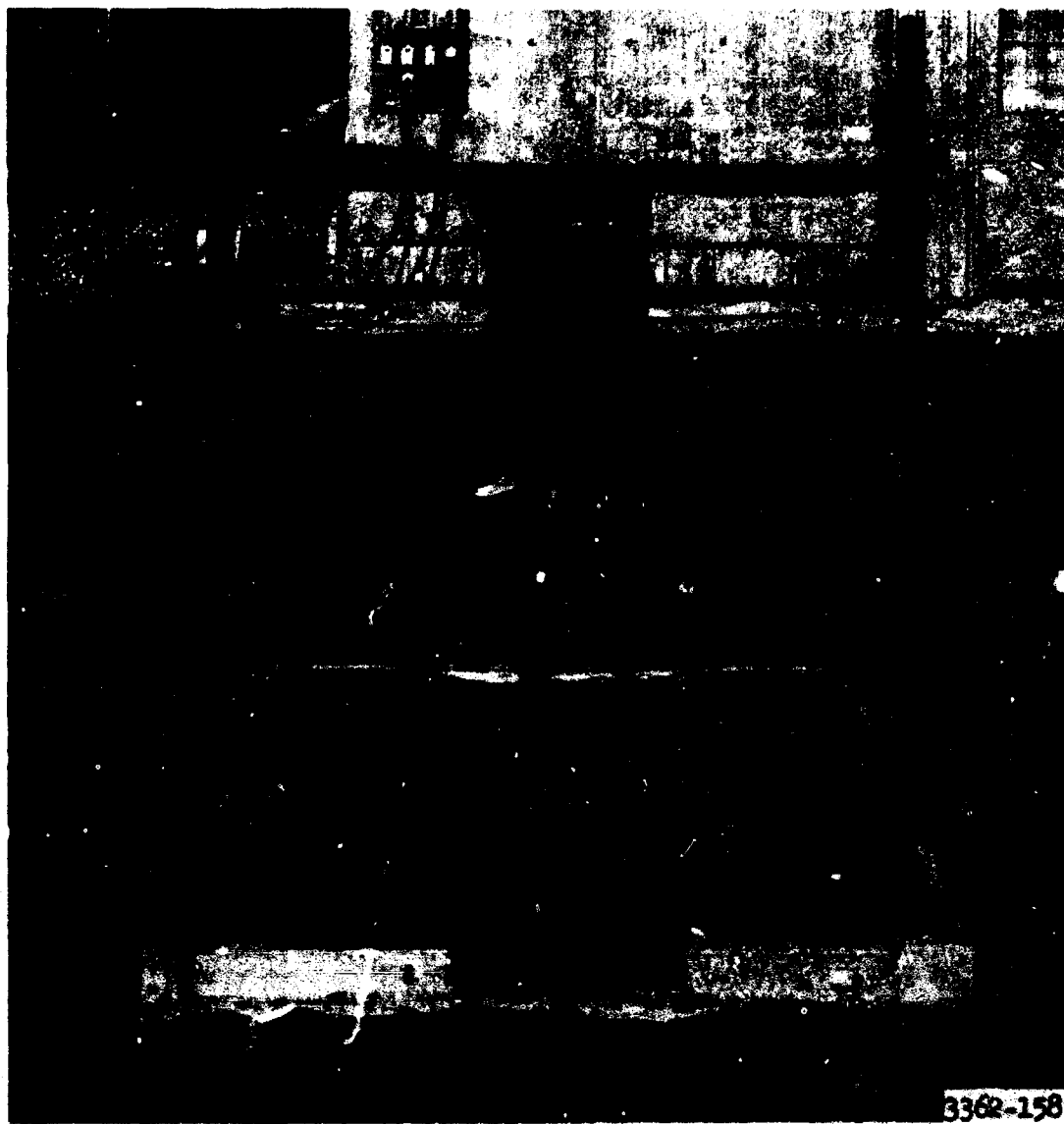
Photograph 4. Untreated loess after testing



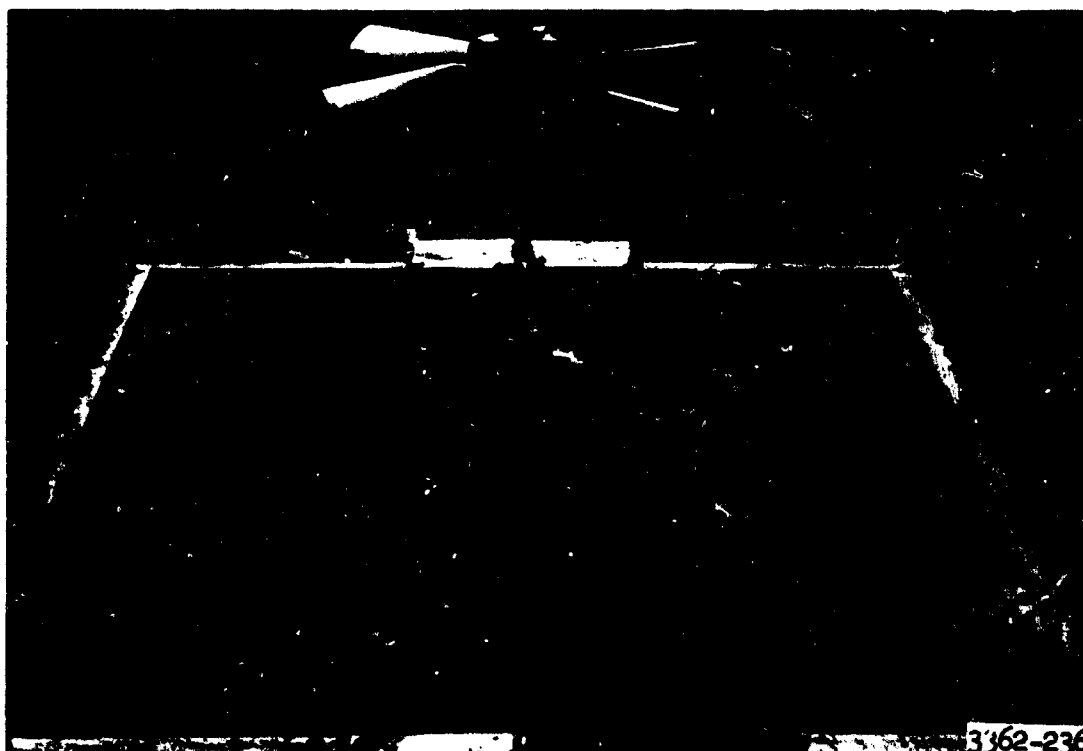
Photograph 5. Untreated Reid Bedford sand before testing



Photograph 6. Untreated Reid Bedford sand during testing



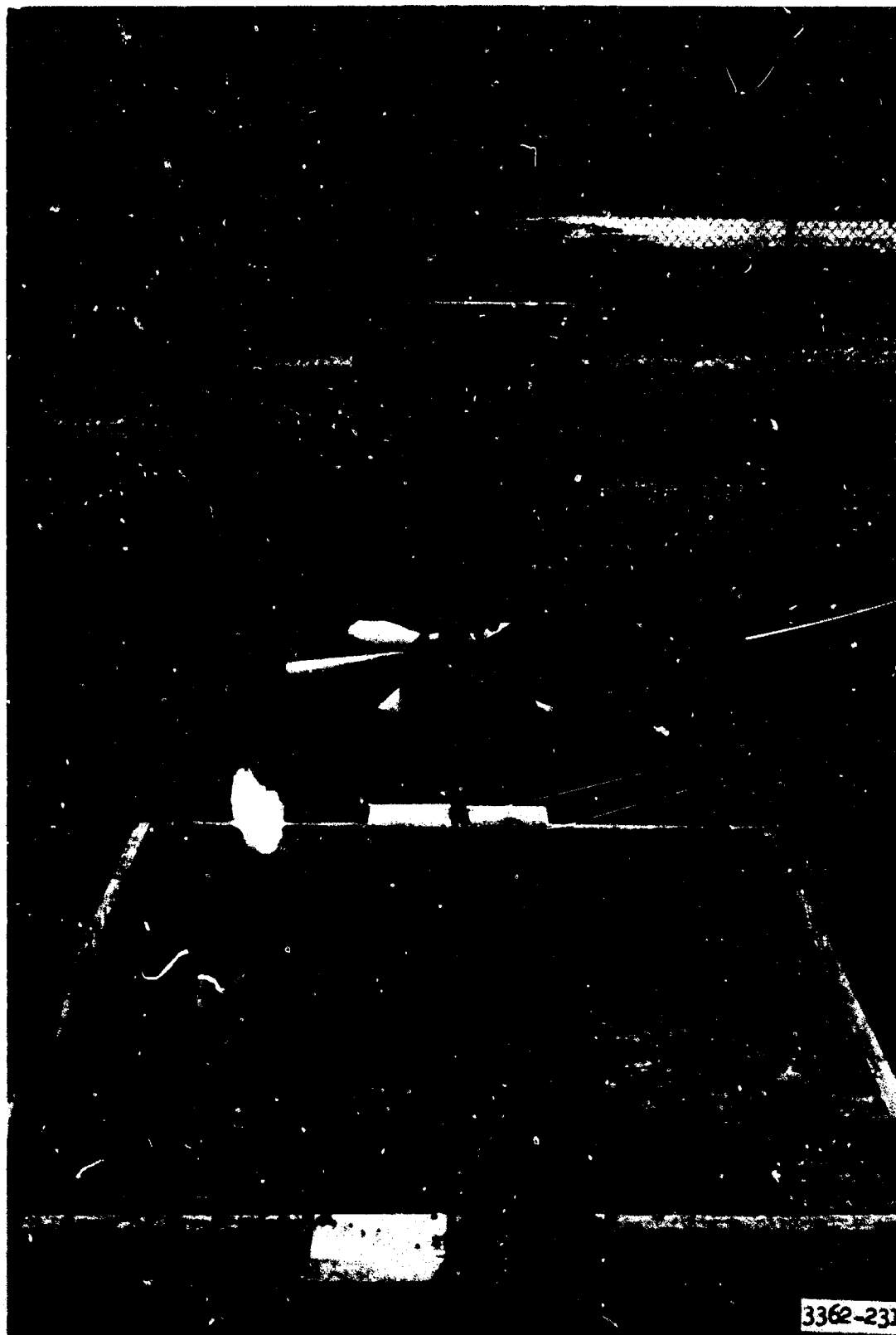
Photograph 7. Untreated Reid Bedford sand after testing



Photograph 8. Loess treated with 1/2 gal resin-base compound before testing

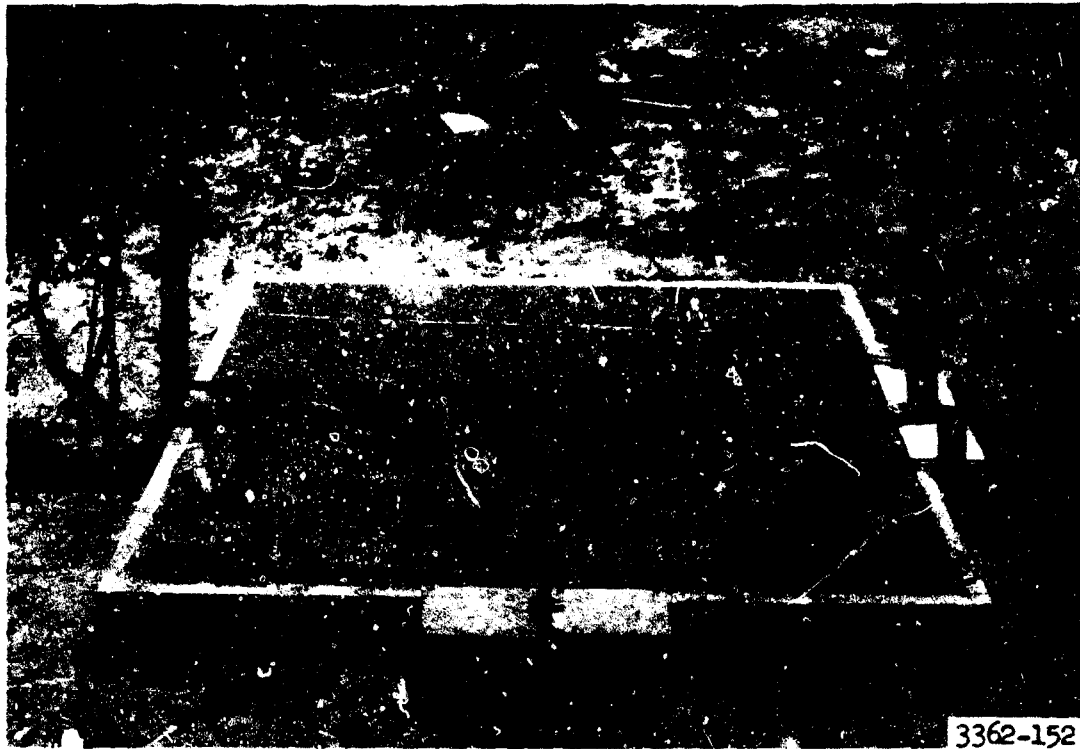


Photograph 9. Loess treated with 1/2 gal resin-base compound during testing

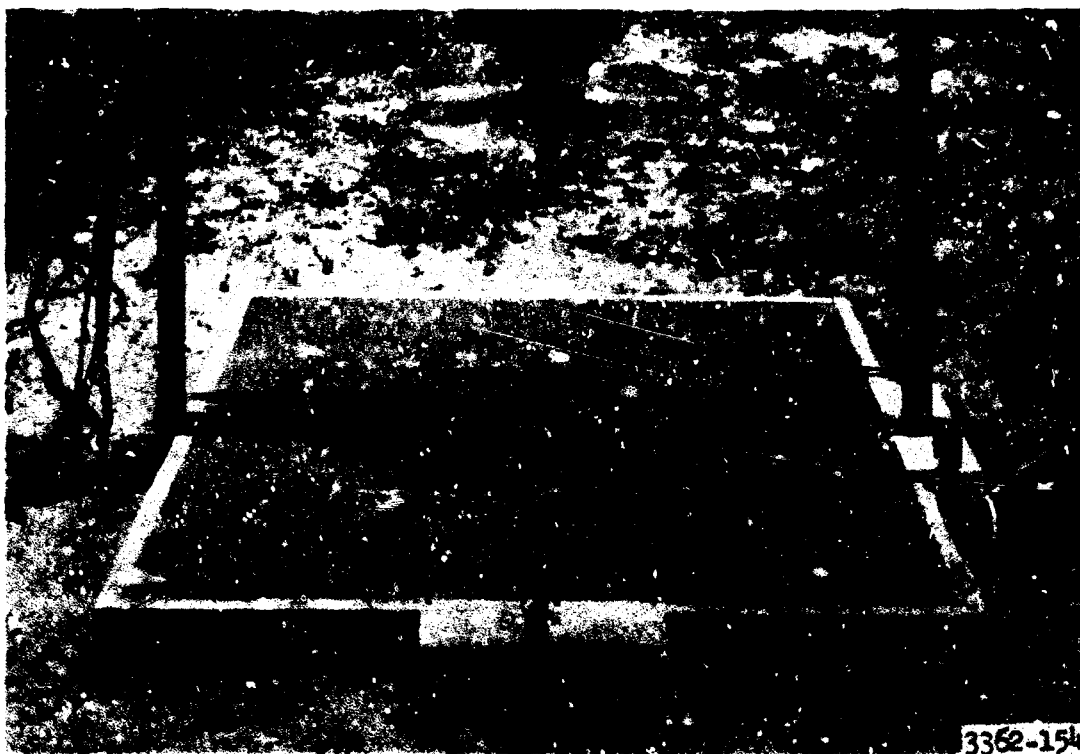


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Photograph 10. Loess treated with 1/2 gal resin-base compound after testing



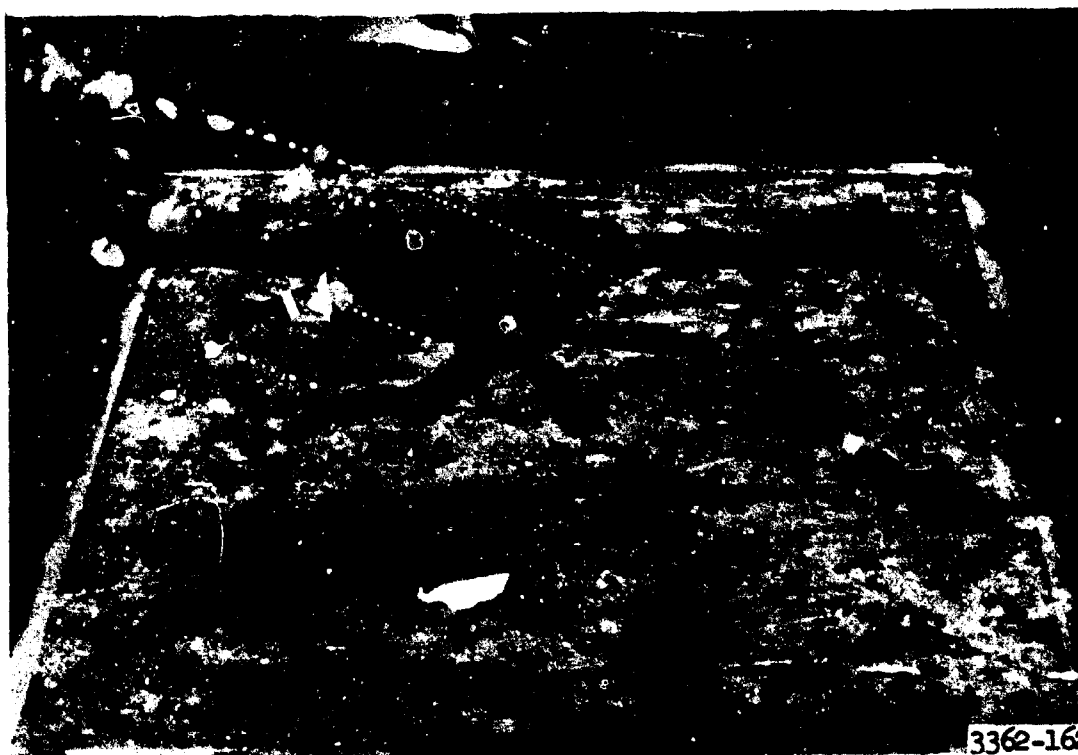
Photograph 11. Reid Bedford sand treated with 1/2 gal
resin-base compound before testing



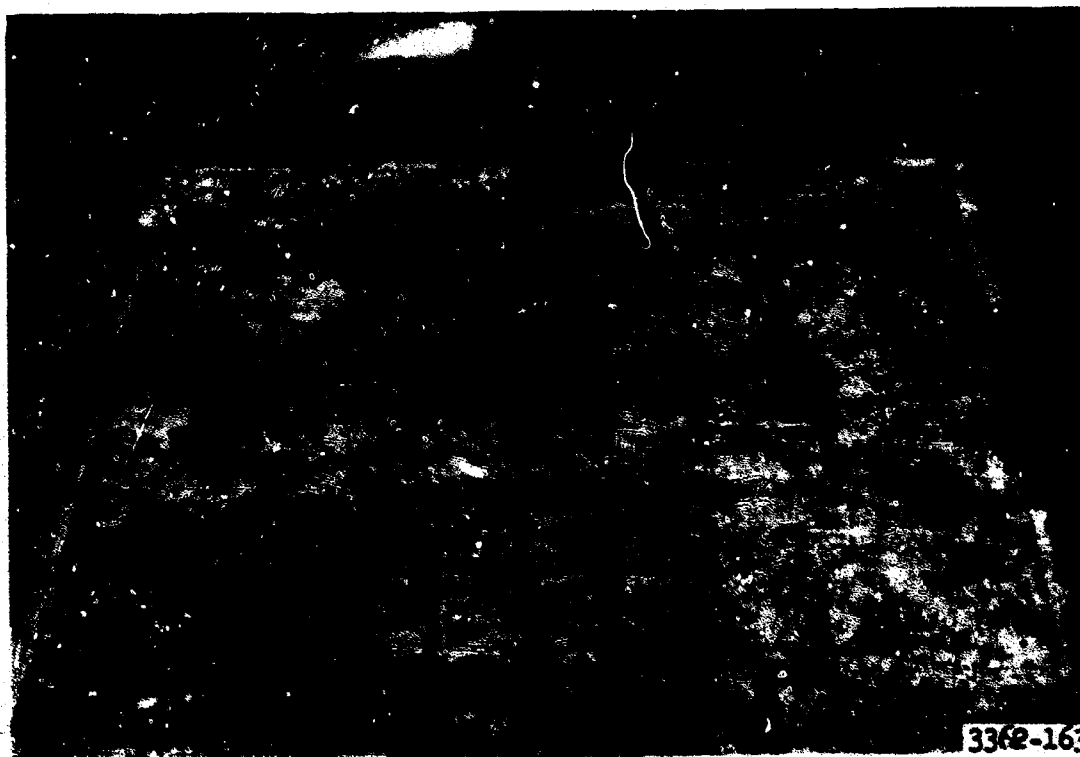
Photograph 12. Reid Bedford sand treated with 1/2 gal
resin-base compound during testing



Photograph 13. Reid Bedford sand treated with 1/2 gal resin-base compound after testing for 120 sec



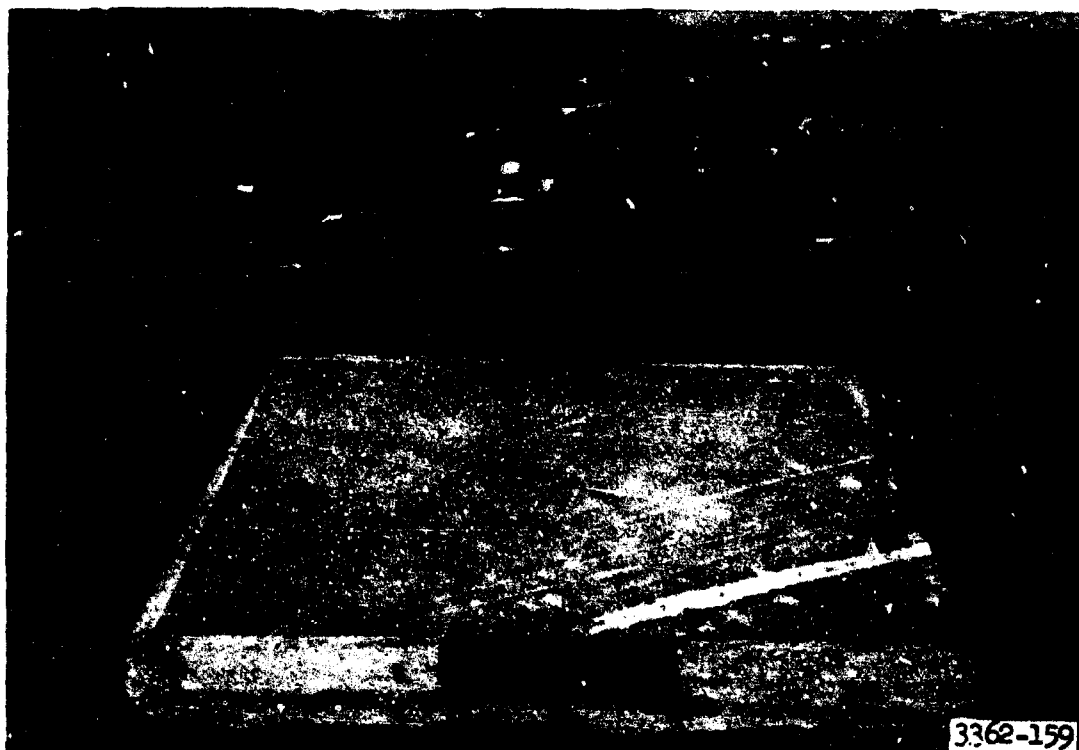
Photograph 14. Loess treated with 1/2 gal latex-base compound before testing



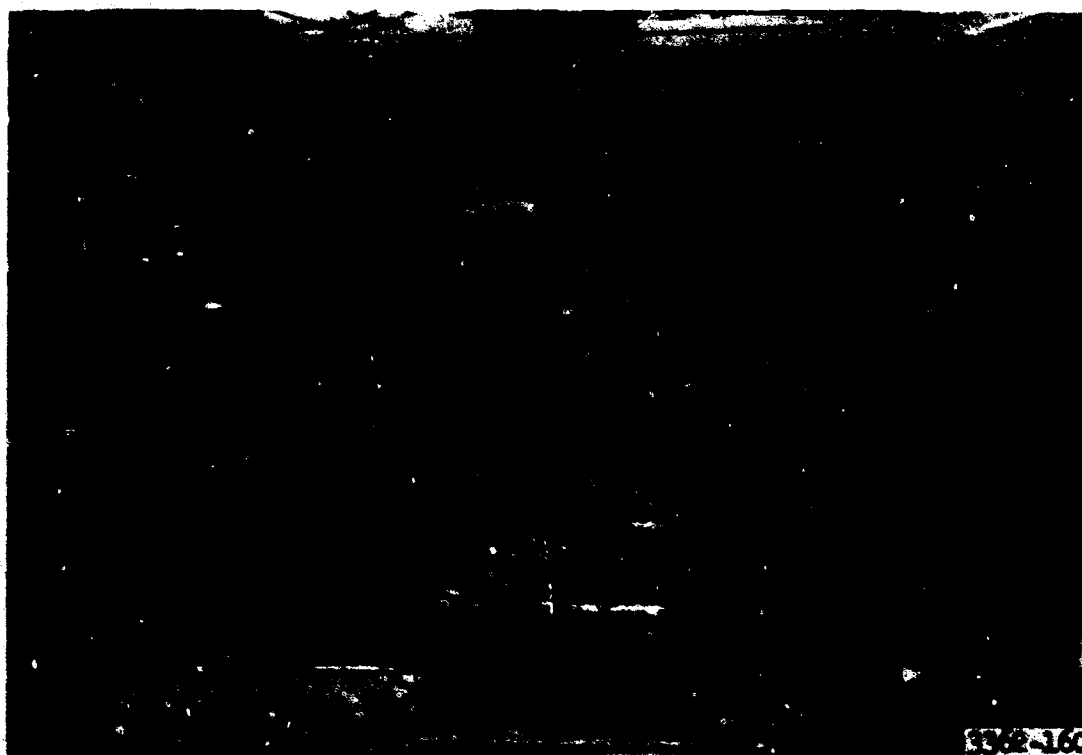
Photograph 15. Loess treated with 1/2 gal latex-base compound during testing



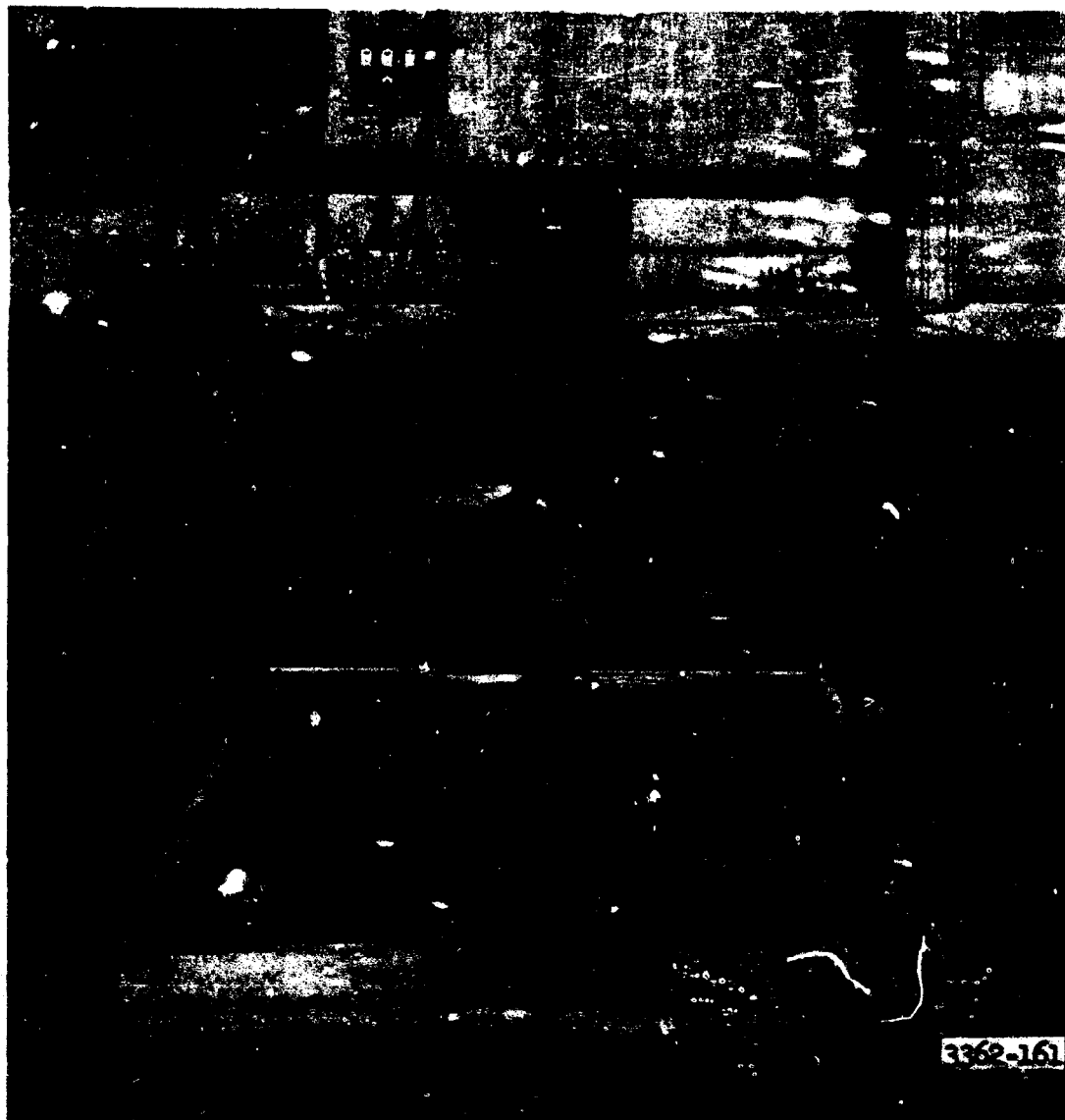
Photograph 16. Loess treated with 1/2 gal latex-base compound after testing (30 sec)



Photograph 17. Reid Bedford sand treated with 1/2 gal
latex-base compound before testing



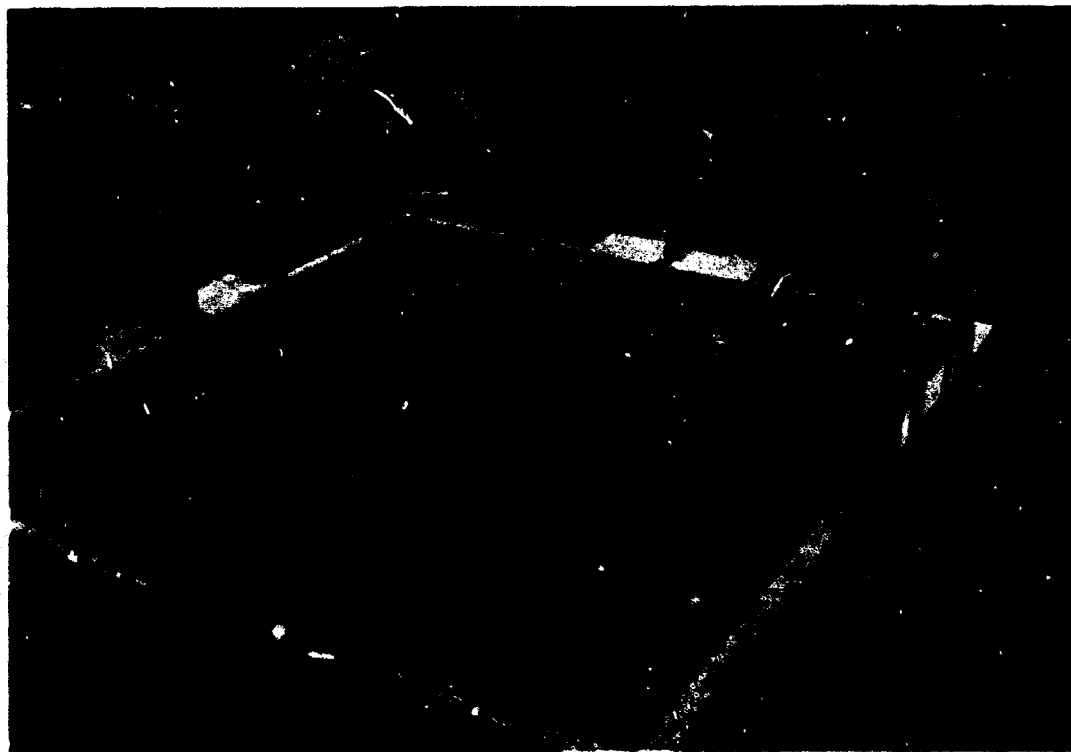
Photograph 18. Reid Bedford sand treated with 1/2 gal
latex-base compound during testing (15 sec)



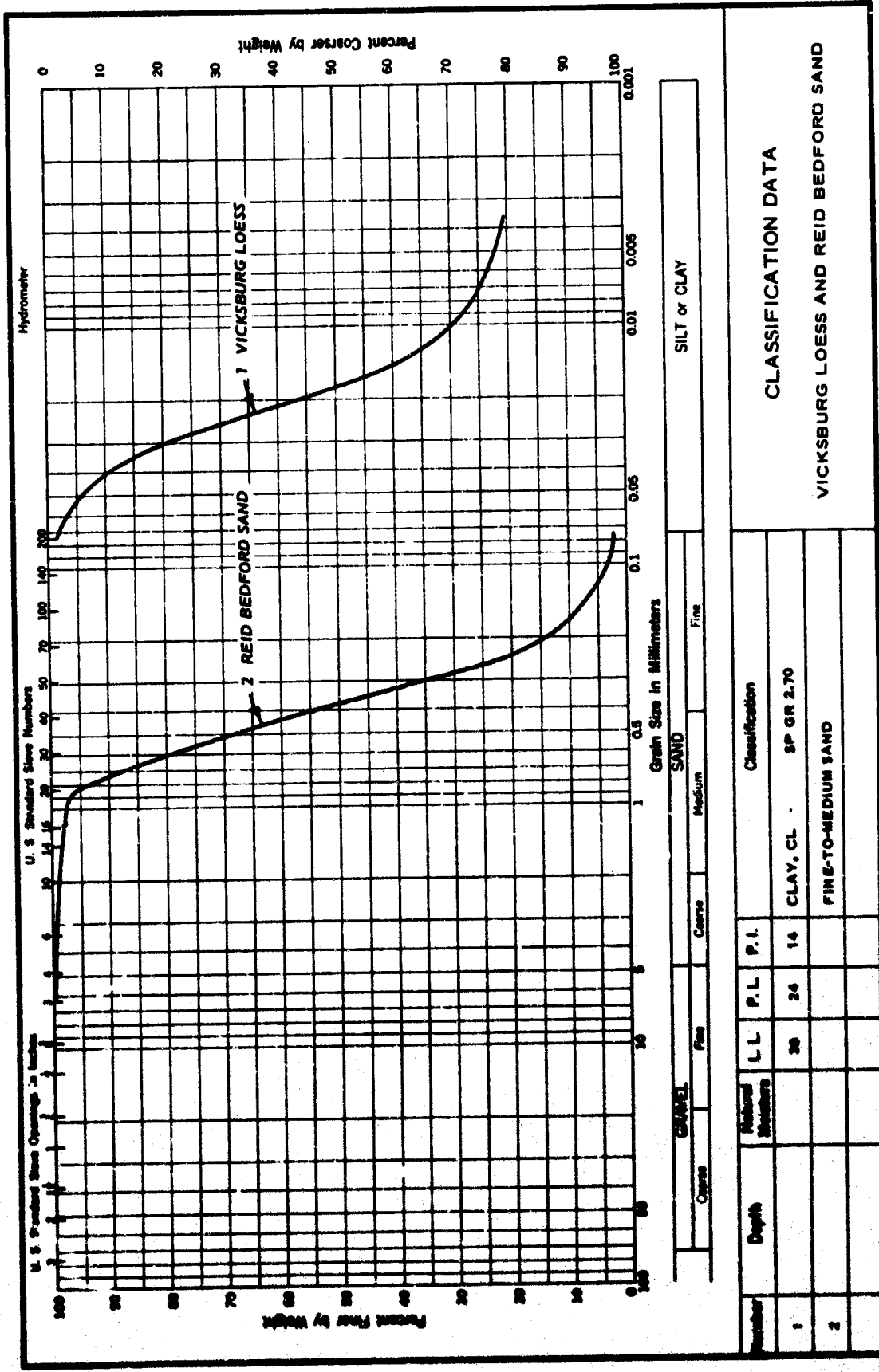
Photograph 19. Reid Bedford sand treated with 1/2 gal
latex-base compound after testing (30 sec)



Photograph 20. Reid Bedford sand treated with 1/2 gal resin-base compound after simulated rain (during testing)



Photograph 21. Reid Bedford sand treated with 1/2 gal resin-base compound after simulated rain (after testing)



CLASSIFICATION DATA

VICKSBURG LOESS AND REID BEDFORD SAND

Number	Depth	Moisture Moisture	L L	P L	P I	Classification
1			30	24	14	CLAY, CL - SP GR 2.70
2						FINE-TO-MEDIUM SAND

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Security Classification

DOCUMENT CONTROL DATA - R&D		
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4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 1 of a series		
5. AUTHOR(S) (Last name, first name, initial) Decell, Joseph L.		
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11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.
13. ABSTRACT Tests were conducted at the U. S. Army Engineer Waterways Experiment Station to evaluate two compounds for use as dust alleviators. The compounds, a resin-base concrete curing compound and a latex-base concrete curing compound, were applied to two different types of materials. One material was Vicksburg loess and the other was Reid Bedford sand. The curing compounds were applied to the two materials, allowed to cure, and tested using a six-blade fan which produced velocities across the material surface averaging approximately 4000 ft per min. As a result of these tests, the following conclusions were made: (a) neither compound could be used in traffic areas; (b) the compounds could be used in such nontraffic areas as the fringe areas of a helicopter landing pad, runway, or rocket launch pad; (c) the resin-base compound performed satisfactorily on sand, but was not satisfactory when applied to the loess; (d) the latex-base compound performed satisfactorily on the loess, but was not satisfactory when tested on sand; (e) when wetted to simulate exposure to rain, the resin-base compound applied to the sand failed under testing. It is recommended that further tests be conducted to evaluate other compounds for use as dust alleviators. These tests should be performed using larger test areas and higher disc loads, with variations in application techniques. These compounds should also be tested under the downwash of a jet engine in order to evaluate their performance under conditions of jet VTOL and STOL aircraft traffic.		

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	ROLE	WT	ROLE	WT	ROLE	WT
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